Dec. 1, 1992

# Filters

## Description

Filters are mechanical methods of removing sediment from storm water before the water leaves a construction site. The filter may consist of pea stone, various grades of washed crushed stone, straw, or one of many types of geotextile materials. This BMP includes specifications for filter fences (silt fences), storm drain inlet protection devices, and several other less common types of filtering mechanisms.

This BMP does not address filter or buffer strips. Buffer/Filter Strips is a separate BMP which contains specifications for preserving and establishing vegetation between erodible areas and water courses to filter sediment. This Filters BMP discusses structural filtering devices.

## Other Terms Used to Describe

Filter Fence
Flotation Curtain
Geotextile Fabric
Sewer Inlet Protection
Silt Curtain
Silt Fence
Storm Drain Inlet Protection

## Pollutants Controlled and Impacts

All filters help retain sediment and attached chemicals, including phosphate, nitrates, metals, and pesticides. The effectiveness of each type of filter is dependent upon the type of material used, design, flow, and proper maintenance. Most filters have limited capacity to control silts and clays, and are most effective in filtering larger sand-sized particles.

By collecting sediment, filters will help reduce the maintenance of storm sewers and other underground piping systems.

## Application

### Land Use

The filters discussed in this practice are most applicable to construction sites.

### Soil/Topography/Climate

Most filters are suitable for retaining sand. Only specialized geotextile materials are suitable for retaining clay, silt and other fine soils. Geotextile materials used to control fine soils clog up quickly, and should be replaced frequently.

### When to Apply

Filters used in conjunction with Check Dams, Sediment Basins, Diversions and areas subject to runoff, should be installed prior to or in conjunction with major earth change activities. Storm sewer inlet filters should be installed as soon as the manhole is capable of receiving storm water.

Geotextile filters should be implemented according to their intended use, and following manufacturer's specifications.

Where to Apply
The location for installing these practices is site-specific and material-specific. See the "Specifications" section, below.

## Relationship With Other BMPs

The following is a list of BMPs and the type of filter most often used in conjunction with them. Refer to the underlined BMP for additional information.

Sediment Basins. Stone is placed around the perforated riser pipe to filter sediment-laden water from runoff, or at the outlet of the sediment basin.

Dewatering operations. Geotextile materials are used to filter soil from water pumped during dewatering.

Diversions. Stone is placed at the hydraulic outlet point.

Check Dams. Although the primary purpose of a check dam is to reduce velocity, it may also be used to filter sediment. Burlap or geotextile bags filled with sand, pea stone or washed crushed stone may be added to the check dam design to provide filtering benefits in addition to reducing the flow velocity.

## Specifications

**General Considerations:**
The filters below are listed according to the specific purpose for which they were intended. Note that straw bales are not recommended as filters, since upon becoming saturated, they swell and act as dams. If straw bales are used, they must be trenched in and replaced before they become water-logged.

Many of the practices below rely on the use of **geotextile materials**. These materials are manufactured to control the rate of storm water flow, and to cause deposition up-slope of the material. They are constructed like a sieve to prevent certain sizes of soil particles from passing through the system, yet allowing water to pass through.

Geotextile fabrics come in a variety of materials. All fabric materials come with permeability, strength and durability ratings. In all cases, follow the manufacturer's recommendations for the specific product application, installation and maintenance. Suppliers of geotextile fabrics are listed in the Appendices.

1. **Protecting storm sewer and catch basin inlets.** Filters are used around catch basins and storm sewer inlets to filter sediment-laden water and maintain the integrity of the storm sewer and/or catch basin. All inlet protection practices should be constructed so that the structure can be easily cleaned out and maintained, and so that any resulting ponded stormwater will not cause excessive inconvenience or damage to adjacent areas or structures. These inlet protection practices are most effective in small drainage areas.

A. Excavated Drop Inlet Sediment Trap. Where the storm sewer can be left below the final grade, a depression in the ground adjacent to the manhole can be an effective way of protecting the sewer. The runoff water is directed to the depression and the sediment allowed to settle out in the pre-fabricated filter. See Exhibit 1 for specifications on this practice.

B. Sod Inlet Filter. This practice should only be used to filter sheet flow in areas which have been final graded and seeded. It is designed to protect the inlet from sediment while all other permanent vegetation is being established. (See Exhibit 2).

C. Geotextile Inlet Filter. This method consists of placing filter fence around the perimeter of the storm inlet. Apply this method where the inlet drains gentle slopes and sheet or overland flow. See Exhibit 3.

D. Geotextile-Stone Filters. These are used both on storm inlets and in street curbs and gutters. Exhibit 4 is simply constructed of geotextile materials over the inlet, with stone on top. The geotextile-stone inlet device may be used when flows in the street are such that if the geotextile filter fabric becomes clogged during a typical storm, the ponded water would not cause damage or inconvenience. Because burlap rots rapidly when it is exposed to sunlight and moisture, use burlap in place of geotextile material only if it is replaced frequently.

E. Exhibit 5, the Modified Geotextile-Stone Filter is used only on curb and gutter inlets. This practice makes use of wire mesh, wood, filter cloth and stone, and should be used to prevent larger volumes of water from ponding in the street. If the geotextile-stone inlet device in Exhibit 4 isn't adequate, modify it according to Exhibit 5 to accommodate greater flows.

F. Block and Gravel Drop Inlet Filter. This practice is used around storm sewers in areas where heavy flows are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure. See Exhibit 6.

G. Block and Gravel Curb and Gutter Inlet Filter. This is similar to the geotextile-stone inlet filters, except that concrete blocks are used. Follow the specifications in Exhibit 7.

2. **Filter Fences.** *When properly installed and maintained,* filter fences are very effective filtering devices adjacent to streams and wetlands. They are most effective on slopes that are not very steep or long. Place at the base of the slope and only in areas of sheet flow. **Do not use in areas of concentrated flow.** Follow the installation and maintenance specifications in Exhibits 8 and 8a.

3. **Filter bags used as part of a dewatering operation.** Geotextile filter bags are often used as part of a Dewatering operation. Water which is pumped from construction activities should be pumped through filter bags, a grass Buffer/Filter Strip, or a Sediment Basin before it enters a water course.

i. The filter bag should be constructed with a needle-punched, non-woven fabric.

ii. The seams of the filter bag may be sewn, nailed between 2" x 4"s, or connected by some positive method of closure. The seams should be strong enough to withstand pumping pressures, sediment loads, and transportation by the contractor to an upland site for disposal.

4. **Floatation silt (turbidity) curtains.** These are silt barriers used in non-flowing water such as a lake or pond. The silt curtain consists of a filter fabric curtain weighted at the bottom and attached to a floatation device at the top. Its purpose is to isolate an active construction area within a lake or stream to prevent silt-laden water from migrating out of the construction area. See Exhibit 9 for specifications for this practice.

5. **Filters as additional protection under structures** and similar practices. Filter fabric can be used under Riprap, and seawalls/retaining walls and other Slope/Shoreline Stabilization structures. Lay filter fabric underneath these structures to allow groundwater seepage and retain soil particles. Consult the "Supplies of Geotextile Filter Fabric," Appendix 6, for specific applications.

6. **Filters as detention berms.** On sites which may benefit from temporary terracing, the developer may opt instead to construct a series of large rock piles (which also act as check dams) along a slope to filter sediment-laden water. See the Check Dams BMP for this application.

7. **Stone filters as outlets for sediment basins and diversions.** The area between a Sediment Basin and a stabilized outlet should consist of stone with or without geotextile material under it. The outlet for a Diversion can also be a stone filter. See also the Stabilized Outlets BMP.

## Maintenance

Effective filters will collect sediment, particularly when the soil is sandy. Filters must be cleaned periodically so they don't become clogged and cause flooding conditions, piping, or overtopping of the control structures. Filter fencing which sags, falls over, or is not staked in, should be promptly repaired or replaced.

## Exhibits

Exhibit 1: Excavated Drop Inlet Sediment Trap. Michigan Soil Erosion and Sedimentation Control Guidebook, and USDA Soil Conservation Service.

Exhibit 2: Sod Inlet Filter. Modified from Virginia Erosion and Sediment Control Manual.

Exhibit 3: Geotextile Inlet Filter. Modified from Virginia Erosion and Sediment Control Manual.

Exhibit 4: Geotextile-Stone Inlet Filter. Virginia Erosion and Sediment Control Manual.

Exhibit 5: Modified Geotextile-Stone Filters for Storm Inlets and Catch Basins. Text: Modified from 1983 Maryland Standards and Specifications for Soil Erosion and

Sediment Control. Graphic: USDA, Soil Conservation Service, College Park, Md.

Exhibit 6: Block and Gravel Drop Inlet Filter. Modified from Virginia Erosion and Sediment Control Manual.

Exhibit 7: Block and Gravel Curb and Gutter Inlet Filter. Modified from Virginia Erosion and Sediment Control Manual.

Exhibit 8: Silt Fence (Filter Fence). Text: Several sources.

Exhibit 8a: Filter Fences. Oakland County, Michigan, Erosion Control Manual.

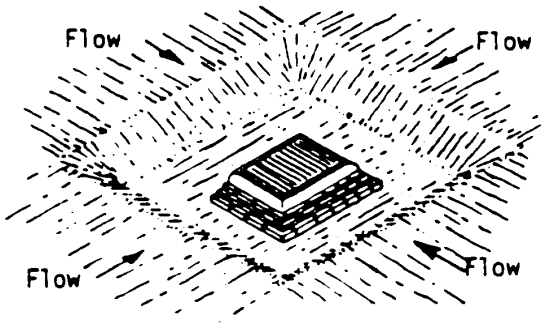
Exhibit 9: Silt (Turbidity) Curtains. Protecting Water Quality in Urban Areas: Best Management Practices for Minnesota.

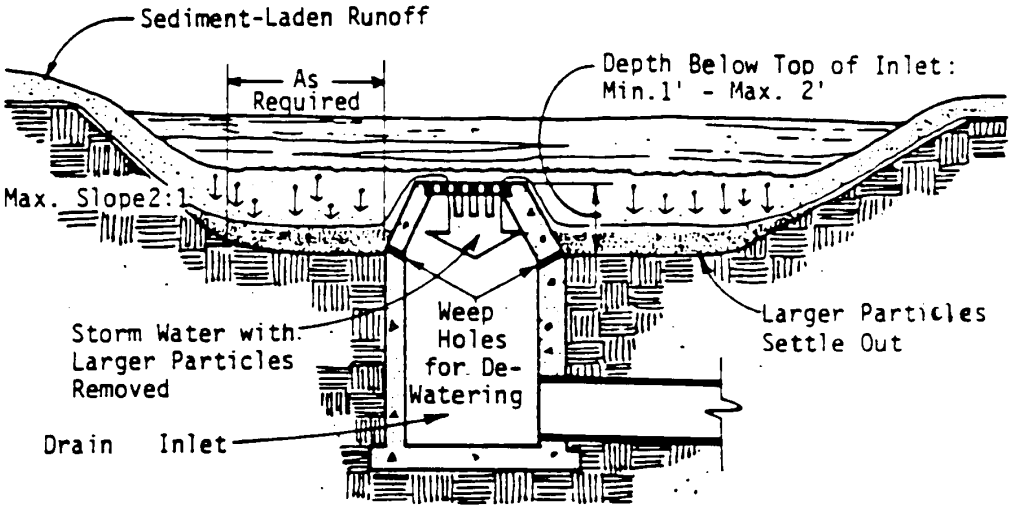
**Exhibit 1**

**Excavated Drop Inlet Sediment Trap**

Use:
Use in areas where heavy flows are anticipated.

1. The excavated trap should be sized to provide a minimum storage capacity calculated at the rate of 135 cubic yards for 1 acre of drainage area. A trap should be no less than 1 foot, nor more than 2 feet deep measured from the top of the inlet structure. Side slopes should not be steeper than 2:1.
2. The slopes of the basin may vary to fit the drainage area and terrain. Observations should be made as necessary to ensure satisfactory trapping of the sediment.
3. Where an inlet is located so as to receive concentrated flows, such as in a highway median, it is recommended that the basin have a rectangular shape in a 2:1 ratio, with the length oriented in the direction of the flow.
4. Sediment should be removed and the trap restored to the original dimensions when the sediment has accumulated to 40% the design depth of the trap. Place any removed sediment in a manner consistent with the Spoil Piles BMP.
5. During final grade, the inlet should be protected with a geotextile-stone filter. Once final grading is achieved, a sod inlet filter should be implemented to protect the inlet until permanent vegetation is established.



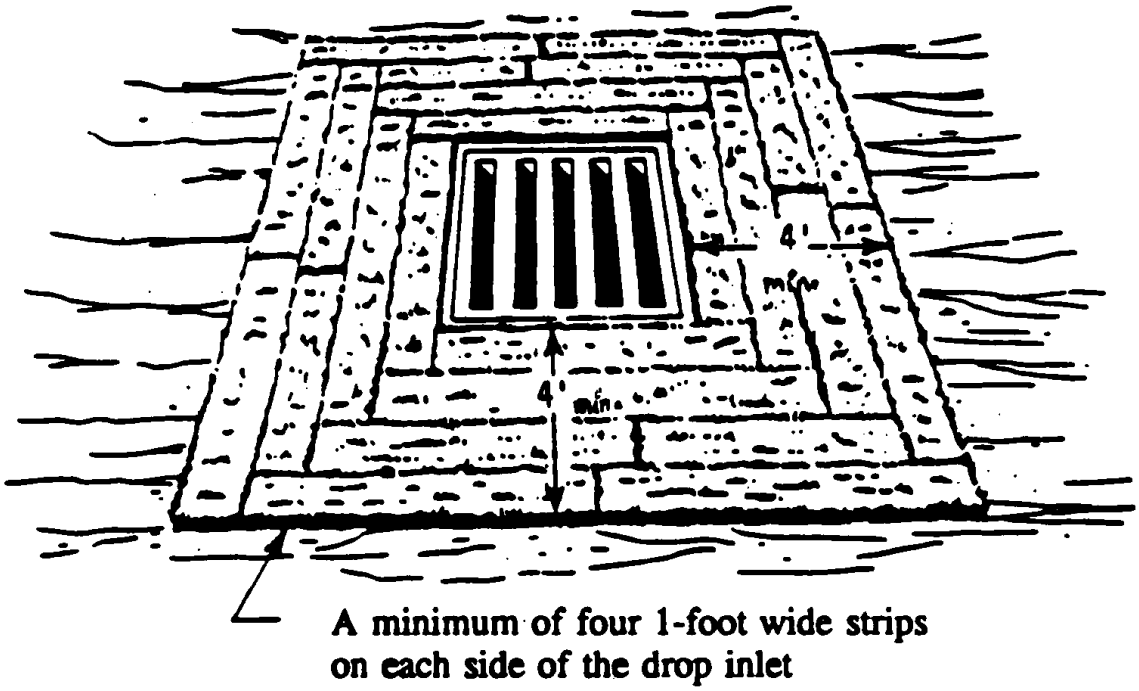

Source: Modified from the Virginia Erosion and Sediment Control Manual.

**Exhibit 2**

**Sod Inlet Filter**

Use:
Use in areas which are not stable on any and all sides. An alternative method to the Burlap or Geotextile Inlet Filter.

1. Use only to filter sheet flow and in areas which have been final graded and seeded for vegetative cover.
2. This practice may be used in conjunction with a stone filter around the inlet.
3. The minimum sod requirement is 4 feet on each side of the inlet. The width of the sodded area should increase based on the slope of the drainage area.
4. Sod should be laid so that the anticipated runoff does not flow directly into the inlet between the pieces of sod. This is best done by laying the sod like masonry bricks (i.e. off-setting every other row.) See Exhibit 3 for the proper placement of the sod.
5. Select sod type, prepare sodbed, lay, and stake sod following the specifications in the Sodding BMP.
6. Maintenance should be done following each rain to ensure the sod is adequately filtering the runoff. Stone filters around the inlet may be added, as necessary.



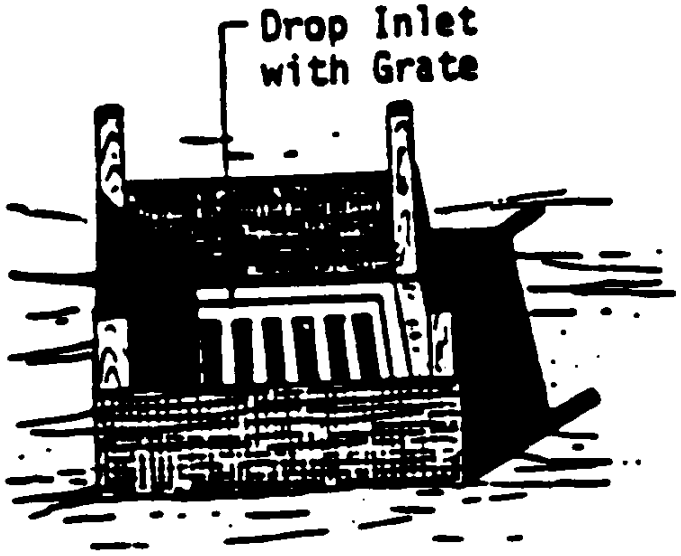

Source: Modified from Virginia Erosion and Sediment Control Manual.

**Exhibit 3**

**Geotextile Inlet Filter**

Use:
Use around the perimeter of inlets in areas which are not stabilized on any or all sides.

1. Filter fabric should have ultraviolet protection and be strong enough to maintain effectiveness under anticipated flows. It should come from a continuous roll and otherwise meet the specifications for filter fabric.
2. Stakes should be 1 1/8" x 1 3/8" finished wood or equivalent metal with a minimum length of 3 feet (36 inches).
3. Staples should be of heavy duty wire at least 1/2-inch long.
4. Stakes should be spaced around the perimeter of the inlet a maximum of 3 feet apart and driven into the ground a minimum of 8 inches.
5. A trench should be excavated around the perimeter of the inlet and the fencing materials placed in the trench. The trench should be 4" wide and 6" deep.
6. Staple the material to the stakes.
7. After lowering the bottom of the material into the trench, backfill with soil and make a small ridge on the up-slope side of the filter material. The geotextile material above the soil should be approximately 16 inches, minimum.
8. The material in the last corner to be completed should overlap with the material from the first one by six inches. Wrap the ends and staple to both posts.




Source: Modified from Virginia Erosion and Sediment Control Manual.

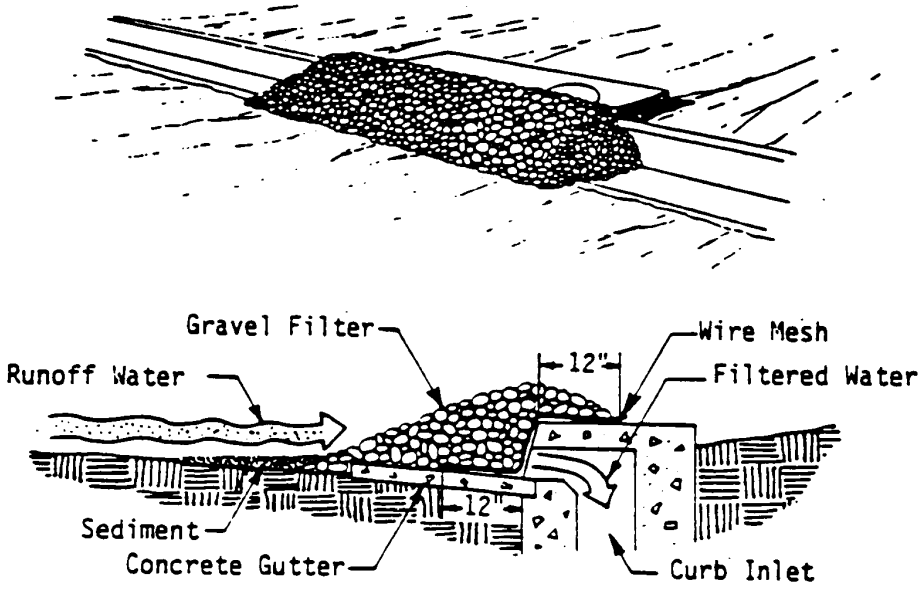
**Exhibit 4**

**Geotextile-Stone Inlet Filters**

Use:
Simple stone filters can be used on storm inlets where flows are minimal. They can consist of laying geotextile or wire material on top of the storm sewer and laying approximately six inches of 2-inch clean aggregate on top. This method can also be used on curb and gutters, though the method in Exhibit 5 is preferred.

Maintenance must be done regularly, especially after storms. When clogging occurs, remove the old geotextile material and stone and replace with new material and either clean stone.

Extra support can be provided by placing hardware cloth or wire mesh across the inlet cover. The wire should be no larger than 1/2" mesh and should extend an extra 12 across the top and sides of the inlet cover. See the diagram below.




Specific Application

This method of inlet protection is applicable at curb inlets where ponding in front of the structure is not likely to cause inconvenience or damage to adjacent structures and unprotected areas.

Source: Modified from Virginia Sediment Control Manual.

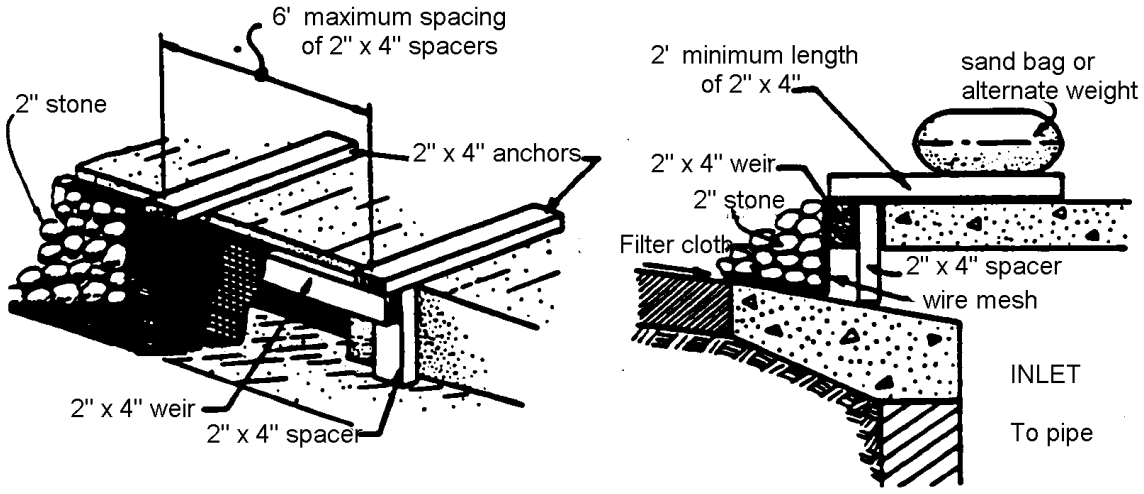
**Exhibit 5**

**Modified Geotextile-Stone Filter**
**For Storm Inlets and Catch Basins**

Use:
Use this method on curb and gutter inlets and storm sewer inlets where overflow capability is needed to prevent excessive ponding in front of the structure.

1. The wire mesh must be of sufficient strength to support filter fabric, and stone for the curb inlets, with water fully impounded against it.
2. The filter cloth must be of a type approved for this purpose, resistant to sunlight, and a sieve size sufficient enough to allow passage of water and the removal of sediment.
3. Use 2" stone. It must be clean.
4. Attach a continuous piece of wire mesh (30" minimum width by throat length plus 4') to the 2" X 4" weir (measuring throat length plus 2') as shown on the drawing.
5. Place a piece of approved filter cloth (40-85 sieve) of the same dimensions as the wire mesh over the wire mesh and securely attach to the 2" X 4" weir.
6. Securely nail the 2" X 4" weir to 9" long vertical spacers to be located between the weir and inlet face (maximum 6' apart).
7. Place the assembly against the inlet throat and nail minimum 2' lengths of 2" X 4" to the top of the weir at spacer locations. These 2" X 4" anchors should extend across the inlet top and be held in place by sandbags or alternate weight.
8. Place the assembly so that the end spacers are a minimum 1' beyond both ends of the throat opening.
9. Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place clean 2" stone over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.
10. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.
11. Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into the inlet.

Modified from 1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control.



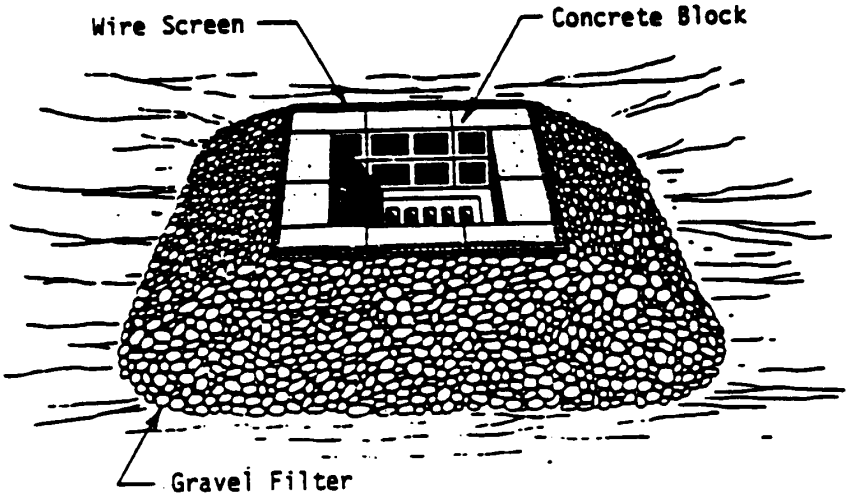

Source: USDA, Soil Conservation Service, College Park, Md.

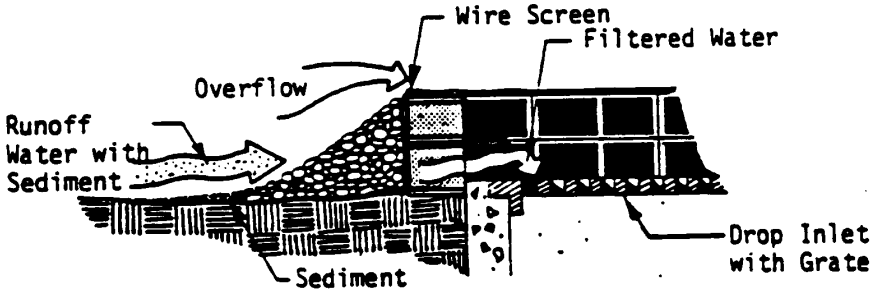
**Exhibit 6**

**Block and Gravel Drop Inlet Filter**

Use:
Use where heavy flows are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure.

1. Place 4" X 8" X 12" concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of the same size blocks. The barrier of blocks should be at least 12 inches high and no greater than 24 inches high.
2. Wire mesh should be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Hardware cloth or comparable wire mesh with 1/2-inch openings should be used.
3. Two-inch stone should be piled against the wire to the top of the block barrier, as shown in the diagram.
4. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced, or new stone replaced.



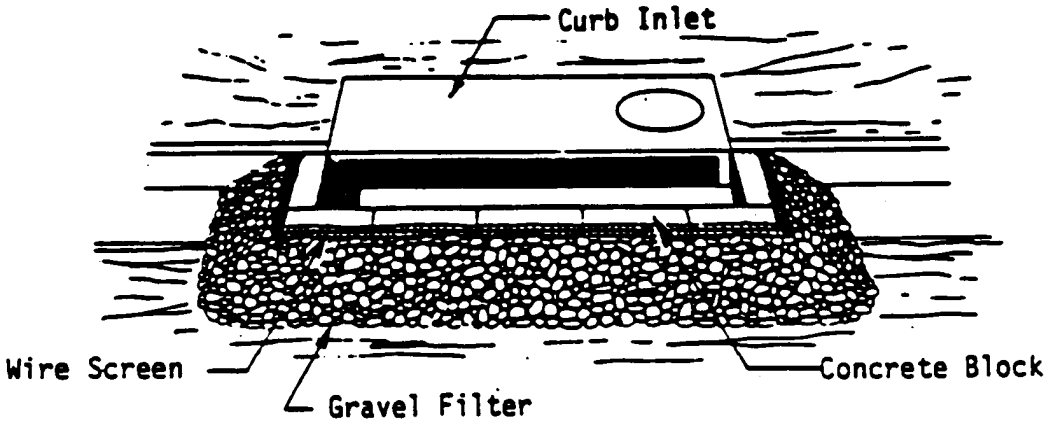

Source: Modified from Virginia Erosion and Sediment Control Manual

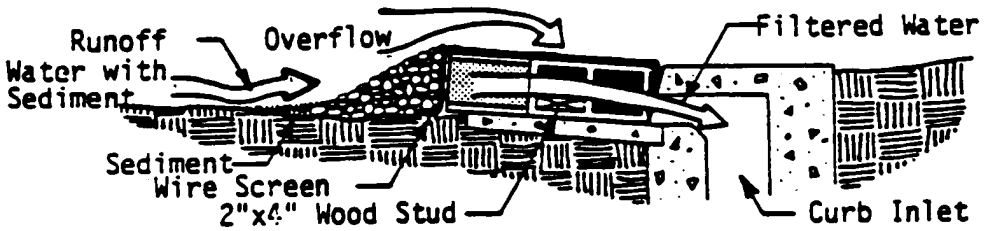
**Exhibit 7**

**Block and Gravel Curb and Gutter Inlet Filter**

Use:
Use this method on curb and gutter inlets and storm sewer inlets where overflow capability is needed to prevent excessive ponding in front of the structure.

1. Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These blocks provide a space between the filtering stone and the inlet.
2. Cut a 2" X 4" stud and place it through the outer holes of each spacer block to keep the front blocks in place.
3. Place additional concrete blocks on their sides across the front of the inlet and abutting the spacer blocks. Refer to the diagram above.
4. Place wire mesh over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Use chicken wire or hardware cloth with 1/2-inch opening.
5. Pile 2" stone against the wire to the top of the barrier, as shown in the diagram.
6. If the stone filter becomes clogged with sediment so that it no longer performs as a filter, the stone must be removed and either cleaned and replaced, or a clean set of aggregate placed.




Source: Modified from Virginia Erosion and Sediment Control Manual.

**Exhibit 8**

**Filter Fences**

Use:
Use to control sheet flow only (not concentrated flow). Use adjacent to critical areas, wetlands and watercourses and at the base of slopes. Slopes should be no steeper than 2:1. Drainage should be 1/2 acre per 100 feet of fence.

Do not use in live streams, ditches or swales.

Specifications:
The fabric should be non-woven and composed of at least 95% propylene or ester polymers. It should be certified by the manufacturer or supplier as conforming to the specifications below. Because of the potential for clogging, non-woven materials are not to be used.

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The following criteria will meet the requirements of Michigan Department of Transportation 1990 Standard Specifications, Section 8.09.06, and should be used as guidance in selecting geotextile filter fencing.

Physical Characteristics

| | |
|---|---|
| Typical fence length: | 100 ft. |
| Fabric width | 24" minimum |
| Post length | 36" minimum |
| Post size | 1 1/8" x 1 3/8" finished |
| Post pointing | Rotary (pencil style) |
| Post composition | No. 1 common hardwood |
| Geotextile/post connection | Stapled or pocketed |

| Mechanical/hydraulic Characteristics: | | Testing Procedure |
|---|---|---|
| Grab tensile strength | 100 lbs. | ASTM D-4632 |
| Trapezoid Tear Strength | 45 lbs. | ASTM D-4533 |
| Mullen Burst Strength | 280 psi | ASTM D-3786 |
| U.V. Resistance | 70% | ASTM D-4355 |
| Water Flow Rate | 30 gpm/sf | ASTM D-4491 |
| AOS | 0.6 mm minimum | ASTM D-4751 |

Source: Price and Company, Inc., Grand Rapids, Michigan.

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Installation:
In most situations, pre-fabricated materials (i.e. those with posts already attached) can be used. However, on rolling terrain, pre-fabricated fences are difficult to install. On rolling terrain, fences should be assembled in the field.

Install along a contour line of equal elevation.

1. Dig a 6-inch trench along the area in which the fence is to be located.
2. Place 6 inches of the bottom of the fabric into the trench. Some manufacturer's include lines on the bottom of the fabric to indicate the approximate 6-inch line. Make sure the fence is taught.

(Con't.)

**Exhibit 8a (Con't.)**

3. Backfill the trench and compact the soil on both sides. Make a small ridge on the up-slope side. (See the Exhibit).
4. Place wooden stakes or metal re-rod a maximum of 7'8" apart. The stakes' re-rod should be pounded into the ground, on the down-slope side, a minimum of 8 inches.
5. Staple the geotextile material onto the wooden stakes using metal staples recommended by the manufacturer (minimum 1/2-inch long). Tie metal posts to the fence with wire.
6. Stabilize the area down-slope of the site with grass and/or sod.

For Reinforcement:

Filter fences can be reinforced with 1/2"-inch mesh wire placed on the down-slope side and supported with 2 X 4s. Use a minimum 14 gage wire and a maximum mesh spacing of 6 inches.

Maintenance

1. Silt fences should be inspected immediately after each rainfall and several times during prolonged rainfalls.

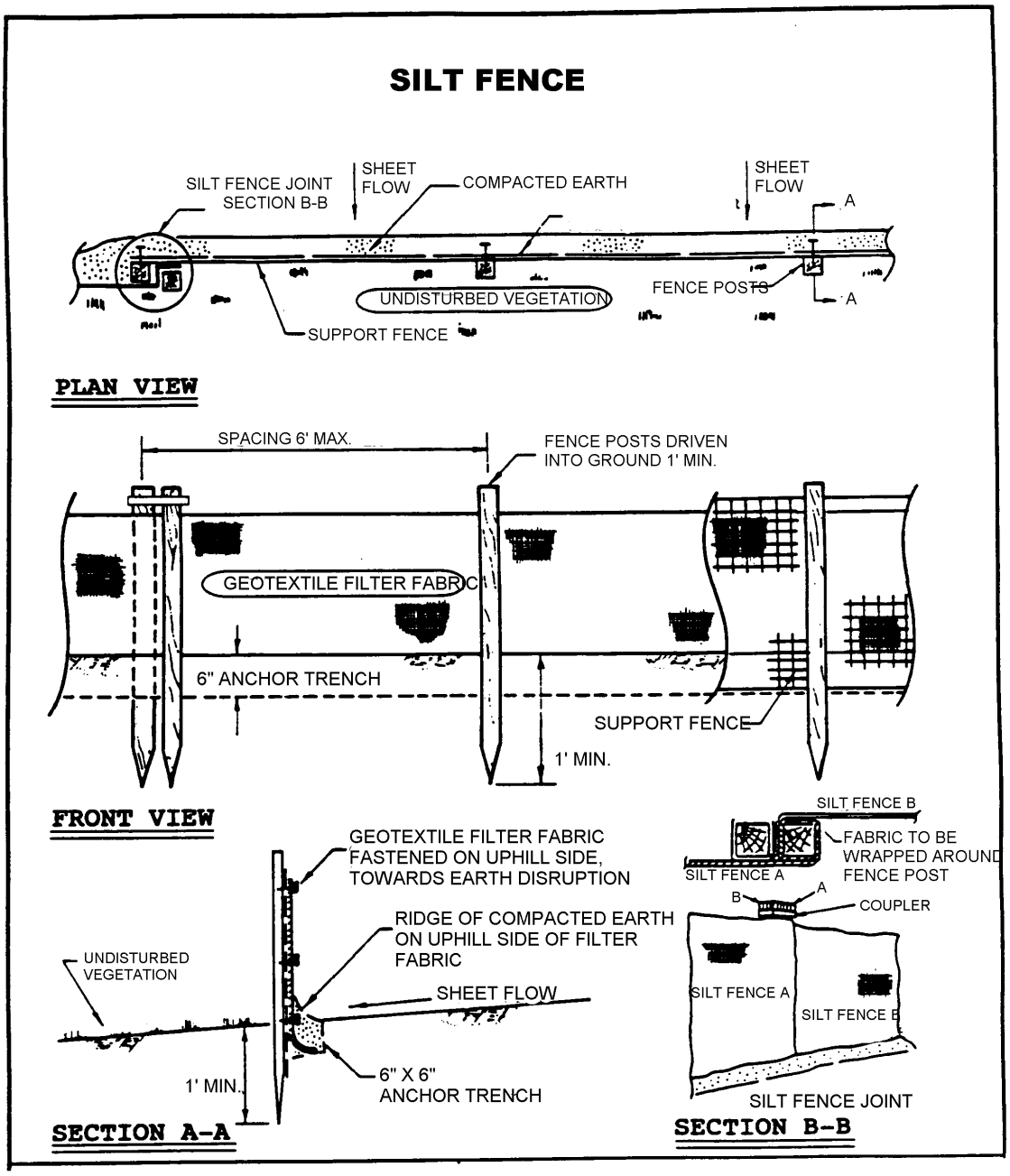
2. If the fence is sagging or the soil has reached one half the height of the fabric, the soil behind the fabric must be removed and disposed of in a stable upland site. The soil can be added to the spoil pile. (See the Spoil Piles BMP).

3. If the fabric is being undercut (i.e. if water is seeping under the fence), the fence should be removed and reinstalled following the procedures given above.

4. Fabric which decomposes or otherwise becomes ineffective should be removed and replaced with new filter fabric immediately.

5. Filter fences should be removed once vegetation is well established and the up-slope area is fully stabilized.

**Exhibit 8a**




Source: Oakland County (Michigan) Erosion Control Manual.

**Exhibit 9**

**Silt (Turbidity) Curtains**

Use:
In lakes adjacent to construction areas and in-stream parallel to the streambank. Used to prevent in-stream sedimentation.

The following specifications are minimum performance standards for suspended solids applications. The following assumptions were made:

-that the primary pollutant is suspended solids (i.e. sand, clay and/or silt). Other types of silt curtains must be used to control other types of pollutants.
-that the silt curtain will be used for no more than one full construction season, (or less, depending on the severity of exposure)

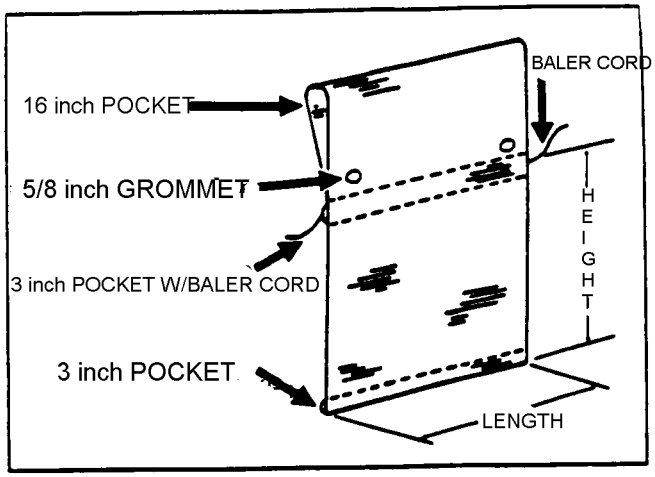
1. The turbidity curtain should be a pre-assembled system including floatation mechanisms, geotextile/geomembrane, bottom weights, securing/tie-off mechanism and joining mechanism.

2. The curtain should be constructed of mechanically-bound, non-woven material consisting of long-chain polymeric fibers. The fibers must be composed of at least 95% propylene or ester polymers. The fibers should be produced in a manner which achieves a stable network.

3. Use Table 1 to determine the appropriate specifications based on the wave height expected in the project area. This table delineates product requirements for a given set of conditions. In no way should a turbidity curtain be extended across or around the flow-path of any inlet structure or waterway without due regard to piping potential, water conveyance needs and clogging potential. If used in streams, the curtain must be placed parallel to the flow of water.

4. Requirements for tie-down locations are site-specific. The number of locations is dependent on the desired shape of the ensuing containment, exterior currents, size of project, etc.

5. Maintain the silt curtain until the construction is stabilized and turbidity is reduced to acceptable levels.




(Con't.)

**Exhibit 9 (Con't)**
**Table 1**

Specifications for Wave Heights Less than 6 Inches:

| Property | Required[1] Value | Unit | Test Procedure |
|---|---|---|---|
| Tensile Strength | 200 | lbs | ASTM D-4632 |
| Tensile Elongation | 50 | % | ASTM D-4632 |
| Mullen Burst | 350 | psi | ASTM D-3786 |
| Trapezoidal Tear Strength | 75 | lbs | ASTM D-4533 |
| Puncture Strength | 100 | lbs | ASTM D-3787[2] |
| Apparent Opening Size (max) | 0.210 | mm | ASTM D-4751 |
| Permittivity | 1.3 | 1/sec | ASTM D-4491 |
| U.V. Resistance (150 hrs.) | 70 | % | ASTM D-4355 |

Specifications for Wave Heights of 6 - 12 Inches:

| Property | Required[1] Value | Unit | Test Procedure |
|---|---|---|---|
| Tensile Strength | 360 | lbs | ASTM D-4632 |
| Tensile Elongation | 50 | % | ASTM D-4632 |
| Mullen Burst | 650 | psi | ASTM D-3786 |
| Trapezoidal Tear Strength | 160 | lbs | ASTM D-4533 |
| Puncture Strength | 225 | lbs | ASTM D-3787[2] |
| Apparent Opening Size (max) | 0.210 | mm | ASTM D-4751 |
| Permittivity | 0.7 | 1/sec | ASTM D-4491 |
| U.V. Resistance (150 hrs.) | 70 | % | ASTM D-4355 |

Specifications for a Minimum Curtain Height of 10 Feet:

| Property | Required[1] Value | Unit | Test Procedure |
|---|---|---|---|
| Tensile Strength | 400 | lbs | ASTM D-4632 |
| Tensile Elongation | 50 | % | ASTM D-4632 |
| Mullen Burst | 700 | psi | ASTM D-3786 |
| Trapezoidal Tear Strength | 160 | lbs | ASTM D-4533 |
| Puncture Strength | 180 | lbs | ASTM D-3787[2] |
| Apparent Opening Size (max) | 0.210 | mm | ASTM D-4751 |
| Permittivity | 0.7 | 1/sec | ASTM D-4491 |
| U.V. Resistance (150 hrs.) | 70 | % | ASTM D-4355 |

[1] The Required Value refers to the average minimum value associated with the geotextile's weaker principal direction (when directional difference is possible).

[2] Tension testing machine with ring clamp; steel ball replaced with a 5/16" diameter solid steel cylinder with flat tip centered within the ring clamp.

Source: Price and Company, Inc. Grand Rapids, Michigan.